United States Department of Agriculture

Forest Service

North Central Forest Experiment Station

Resource Bulletin **NC-89**

Future Timber Harvest on the Chippewa and Superior National Forests in Minnesota

Blair Orr, Joseph Buongiorno, Timothy Young, David C. Lothner, and Edwin Kallio

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication March 28, 1985
1985

FUTURE TIMBER HARVESTS ON THE CHIPPEWA AND SUPERIOR NATIONAL FORESTS IN MINNESOTA

Blair Orr, *Research Assistant*,
Joseph Buongiorno, *Professor*,
Timothy Young, *former Research Assistant,*
Department of Forestry, University of Wisconsin-Madison,
David C. Lothner, *Principal Economist,*
and **Edwin Kallio**, *Principal Market Analyst,*
Duluth, Minnesota

The two national forests in Minnesota—the Chippewa and the Superior—contain about 15 percent of the commercial forest land in the northeasternmost 17 counties of the State. The timber harvest from these forests is critical to the local forest industries, partly because so much of the forest land in northern Minnesota has been withdrawn from commercial use (e.g. the Boundary Waters Canoe Area Wilderness and Voyageurs National Park). So there is much local and regional interest in the future demand for timber from the national forests. Our efforts to project these demands are reported here.

Aspen-birch is the predominant forest type in both these forests. The Chippewa covers 590,500 acres of forest land, of which 562,300 are commercial. About 46 percent of the Chippewa's commercial forest land is in the aspen-birch type, 16 percent is in various pine types, and 13 percent is in the spruce-fir type (Jakes and Raile 1980). The Superior National Forest covers 2,008,900 acres of which 1,152,800 acres are commercial. About 47 percent of the Superior National Forest's commercial forest land is in the aspen-birch type and 28 percent is the spruce-fir type (Spencer and Ostom 1979).

The pulp and paper industry has played a significant role in the northern Minnesota economy and has been a major consumer of national forest timber in Minnesota, primarily aspen. Aspen production has been increasing steadily over the last several decades and by 1982 amounted to 62 percent of the roundwood pulpwood harvested.

Sawmilling is less prominent in the area. About 230 million board feet of saw logs were produced in 555 sawmills in Minnesota in 1980. About 35 percent of the total saw log production was aspen; 34 percent was red pine, jack pine, white pine, and other softwood species; and 31 percent was red oak, elm, ash, and other hardwoods. About 86 percent of all Minnesota sawmills were located in 17 northern counties.

Fuelwood use in northern Minnesota increased approximately 450 percent from 1970 to 1980 (Minnesota DNR 1981b), although little of this has come from the growing stock of either the Chippewa or Superior National Forests.

Recent technological innovations combined with a readily available supply of aspen have led to a major expansion in the waferboard industry in northern Minnesota.

Other studies of the demand for timber look at a broader geographical area that includes the two National Forests. Regional forecasts of timber harvest are reported in "An Analysis of the Timber Situation in the United States, 1952-2030" (USDA 1982). This is a national document that cannot include local demand factors such as the waferboard industry of northern Minnesota. Rockel *et al.* (1983) have projected consumption levels of timber grown in northern Minnesota but do not detail timber harvest on the National Forests. Data Resources, Inc. (DRI) (1980) studied the demand for Minnesota timber but does not give detailed information for the National Forests. Our paper and the DRI study make similar assumptions regarding population growth and housing starts but use different forecasting methods. The DRI study analyzes regional data while our study synthesizes local demands. Erkkila *et al.* (1982) projected economic impacts of expansion of forest industries in northeastern Minnesota but did not include specific projections for the Superior National Forest. Other reports project consumption of wood residue (Minnesota DNR 1980), consumption of aspen (Jakes 1981), and consumption by particular end uses, such as fuelwood and waferboard (Minnesota DNR 1981a, Minnesota DNR 1981b, Carpenter 1981, Koch and Springate 1983).

METHODS

We followed the general procedure used by Rockel *et al.* (1983). Total harvest is divided into the harvest of pulpwood, sawtimber, and fuelwood by three species groups: softwoods, aspen, and other hardwoods. Trends within each of these groups are compared with trends within the same species and product groups within a larger geographical area, either northern Minnesota or the northern region of the United States. Estimates of harvests for each of the species and product groups are projected for selected years between 1985 and 2030.

Because data available for consumption of aspen by the waferboard industry are limited, a different model was used to generate forecasts of future consumption of aspen by this industry. The model does not attempt to differentiate between pulpwood and sawtimber size class used by the waferboard industry.

We base our projections on several assumptions. We assume a limited substitution of other species for aspen, particularly in the waferboard and pulp and paper industries. In estimating future population growth, we assume a fertility rate of 2.1 children per woman. Finally, we assume that timber growth rates on the National Forests will increase from 0.33 in 1985 to 0.42 cords per acre per year by 2030.

We chose the forecasting method for this study for two reasons. First, we assumed that the timber harvested on the Chippewa and Superior National Forests does not influence price. Connaughton and Haynes (1983) concur in this assumption when the National Forest's share of the market is small, as is the case here. The Superior National Forest controls a larger market share than does the Chippewa National Forest, yet it supplies only 12 percent of the timber harvested in northern Minnesota. Moreover, during 1980, 16.2 percent of the pulpwood harvested in Minnesota was exported to Wisconsin and 5.5 percent to other states (Blyth and Smith 1982), further diluting the ability of either National Forest to influence price. Second, data with which to build a sophisticated price-sensitive model are limited for a small regional study.

Other studies (Haynes 1977; Adams 1977; Haynes, Connaughton, and Adams 1981; Adams 1983) have used other approaches. However, these studies discuss demand (1) by region rather than by forest, (2) in areas where the Forest Service controls a larger share of the market, or (3) in areas where more data are available.

PULPWOOD HARVESTS

Together, the Chippewa and Superior National Forests supply approximately one-fifth of the pulpwood harvested in northern Minnesota. This is slightly more than the national forest share of commercial forest land in northern Minnesota. During the period from 1964 to 1981, the Chippewa National Forest pulpwood harvest ranged from 60 to 98 thousand cords, with no apparent trend. This amounted to an average of 7 percent of the northern Minnesota harvest (table 1). The Superior National Forest harvest over the same period has ranged from 86 to 178 thousand cords per year, an average of 12 percent of the northern Minnesota harvest, again with no apparent trend (table 1).

Rockel *et al.* (1983) projected pulpwood consumption of timber grown in northern Minnesota. Using their medium projections, and assuming the Chippewa and Superior National Forests will maintain 7 and 12 percent shares, respectively, of the pulpwood harvest in northern Minnesota, we calculated harvest projections for the Chippewa and Superior National Forest through 2030 (table 2).

Accordingly, we project that the pulpwood harvest could increase 83 percent, to 177,000 cords on the Chippewa National Forest and to 303,000 cords on the Superior National Forest by 2030. The largest increases will be in the aspen harvest—150 percent on both of the National Forests. Aspen could account for 84 percent of the total pulpwood volume harvested on each of the forests. Softwood harvest is projected to decline 40 percent. Although other hardwood harvests are projected to increase in approximately the same proportion as aspen, the total volume harvested will remain small: 10,000 cords on the Chippewa and 18,000 cords on the Superior by 2030. The similarity of trends in projected harvest of aspen and other hardwoods reflects a moderate substitution of other hardwoods for aspen by the industries that use aspen as a raw material.

SAWTIMBER HARVESTS

The sawtimber harvest has varied on the Chippewa and Superior National Forests (tables 3 and 4). It decreased from 1964 to 1978, but since then the trend has reversed and harvests are increasing.

Because only limited data are available for sawtimber harvests in northern Minnesota and the northern region of the United States, we could not compare them with the two National Forests. So, we simply assumed that total sawtimber harvest on the

Table 1.—*Harvest of pulpwood in northern Minnesota, and on the Chippewa and superior National Forests*

(In thousand cords)

Year	Northern Minnesota[1]	Chippewa National Forest		Superior National Forest	
		Volume[2]	Percent	Volume	Percent
1964	1,044	60	6	168	16
1965	998	62	6	154	15
1966	1,149	63	5	135	12
1967	1,148	75	7	145	13
1968	1,023	72	7	123	12
1969	1,127	69	6	95	8
1970	1,115	83	7	148	13
1971	1,083	79	7	165	15
1972	1,212	98	8	137	11
1973	1,219	73	6	143	12
1974	1,389	81	6	126	9
1975	1,220	63	5	152	12
1976	1,171	93	8	144	11
1977	1,173	82	7	105	9
1978	1,168	90	8	113	10
1979	1,281	96	8	138	11
1980	1,193	73	6	96	8
1981	1,232	65	5	86	7
Mean			7		12
Standard deviation			1		3

[1]Blyth (1966-1975); Blyth and Hahn (1976-1978); Blyth and Smith (1979-1982).

[2]U.S. Department of Agriculture, Forest Service. Unpublished reports on timber cut and sold from Region 9 National Forests, Milwaukee, WI.

Chippewa and Superior National Forests will increase in proportion to that in the northern region of the United States.

We assume the same forces that drive demand for sawtimber in the northern region of the United States drive demand on the Chippewa and Superior National Forests. So, the Chippewa and Superior National Forests mean shares of the northern region harvest (table 5) were used to project the sawtimber harvest on each National Forest through 2030 (table 6).

The mean species group share values from tables 3 and 4 and the total projected harvest levels from table 6 were used to project the species group harvest levels for each National Forest through the year 2030 (tables 7 and 8). The data from 1979 to 1982 are omitted from tables 5 and 6 because volumes are thought to be influenced heavily by the waferboard industry. Projections for timber used by the waferboard industry are made separately.

Harvest of sawtimber is projected to increase 52 percent on each forest. Softwoods will account for

Table 2.—*Projected pulpwood harvest on the Chippewa and Superior National Forests through 2030*

(In thousand cords)

Year	Northern Minnesota[1]			Chippewa National Forest			Superior National Forest		
	Softwoods	Aspen	Other hardwoods	Softwoods	Aspen	Other hardwoods	Softwoods	Aspen	Other hardwoods
1985	464	883	51	32.4	60	4.3	55.7	103	7.4
1990	475	990	69	33.3	69	4.8	57.0	119	8.3
2000	455	1,290	90	31.9	90	6.3	54.6	155	10.8
2010	342	1,516	106	23.9	106	7.4	41.0	182	12.7
2020	352	1,784	125	24.6	125	8.8	42.2	214	15.0
2030	263	2,115	148	18.4	148	10.3	31.5	254	17.8

[1]Rockel *et al.* (1983).

Table 3.—*Sawtimber harvest by species group on the Chippewa National Forest*[1]

(In thousand board feet, Scribner Decimal C)

	Softwoods		Aspen		Other Hardwoods		
Year	Volume	Percent of total	Volume	Percent of total	Volume	Percent of total	Total
1964	4,786	43	4,442	40	1,897	17	11,125
1965	6,213	60	2,656	26	1,423	14	10,292
1966	3,836	35	5,361	49	1,835	16	11,032
1967	6,108	52	3,786	32	1,794	16	11,688
1968	5,552	46	4,129	34	2,338	20	12,019
1969	3,495	39	4,522	50	1,008	11	9,025
1970	4,885	52	2,370	25	2,071	23	9,326
1971	4,291	60	1,596	22	1,219	18	7,106
1972	4,675	80	19	1	519	19	5,213
1973	4,221	68	1,051	17	933	15	6,205
1974	4,788	77	1,073	17	870	6	6,731
1975	3,816	78	470	10	619	12	4,905
1976	4,204	63	1,171	18	1,269	19	6,644
1977	4,186	79	140	3	944	18	5,270
1978	4,272	72	501	8	1,159	20	5,932
Mean		60		23		17	

[1]Data from unpublished records of timber cut and sold in Region 9 National Forests, Milwaukee, WI.

Table 4.—*Sawtimber harvest by species group on the Superior National Forest*[1]

(In thousand board feet, Scribner Decimal C)

	Softwoods		Aspen		Other Hardwoods		
Year	Volume	Percent	Volume	Percent	Volume	Percent	Total
1964	4,247	54	2,119	27	1,577	19	7,943
1965	5,708	69	1,054	13	1,470	18	8,232
1966	4,693	59	1,765	22	1,541	19	7,999
1967	7,639	74	1,442	14	1,283	12	10,364
1968	8,949	79	1,421	13	887	8	11,257
1969	7,557	74	1,839	18	765	8	10,161
1970	7,764	79	1,158	12	928	9	9,850
1971	4,244	60	2,090	29	758	11	7,092
1972	6,664	76	1,434	17	582	7	8,680
1973	4,933	56	2,922	33	954	11	8,809
1974	6,967	67	2,652	26	779	7	10,398
1975	4,277	77	1,007	18	290	5	5,574
1976	4,457	56	2,578	33	875	11	7,910
1977	3,099	72	971	23	215	5	4,285
1978	3,671	64	1,359	24	731	12	5,961
Mean		68		21		11	

[1]Data from unpublished records of timber cut and sold in Region 9 National Forests, Milwaukee, WI.

Table 5.—*Saw log harvest in the Northern Region and on the Chippewa and Supeiror National Forests*

(In thousand board feet, Scribner Decimal C)

	Northern Region[4]	Chippewa National Forest		Superior National Forest	
Year	Volume	Volume[2]	Regional percent	Volume	Regional percent
1970	7,082,000	9,326	13	9,850	14
1975	6,946,000	4,905	7	5,574	2
1976	6,294,000	6,644	11	7,910	13
1980	6,810,000	10,394	15	12,798	19
Mean			12		14

[1]1975 data from Rockel *et al.* (1983). Data for 1970, 1976, and 1980 from USDA (1982b).
[2]Data from unpublished records of timber cut and sold in Region 9 National Forests, Milwaukee, WI.

Table 6.—*Projected sawtimber harvest on the Chippewa and Superior National Forests*

(In million board feet, Scribner Decimal C)

Year	Northern Region[1]	Chippewa National Forest	Superior National Forest
1985	6,674	8.01	9.34
1990	6,545	7.85	9.16
2000	7,674	9.21	10.74
2010	8,784	10.54	12.30
2020	9,969	11.96	13.96
2030	10,908	13.09	15.27

[1]Projections from USDA (1982b).

Table 7.—*Projected sawtimber harvest on the Chippewa National Forest by species group*

(In million board feed, Scribner Decimal C)

Year	Total	Softwoods	Aspen	Other hardwoods
1985	8.01	4.81	1.84	1.36
1990	7.85	4.71	1.80	1.33
2000	9.21	5.52	2.12	1.56
2010	10.54	6.32	2.42	1.79
2020	11.96	7.18	2.75	2.03
2030	13.09	7.85	3.01	2.22

Table 8.—*Projected sawtimber harvest on the Superior National Forest by species group*

(In million board feed, Scribner Decimal C)

Year	Total	Softwoods	Aspen	Other hardwoods
1985	9.34	6.35	1.96	1.03
1990	9.16	6.23	1.92	1.01
2000	10.74	7.31	2.26	1.18
2010	12.30	8.36	2.58	1.35
2020	13.96	9.49	2.93	1.54
2030	15.27	10.38	3.21	1.68

more than half of the harvest in each case. Rockel *et al.* (1983) projected a 53 percent increase in sawtimber harvested from northern Minnesota with a larger increase in aspen sawtimber harvest. This difference is due to the separation of aspen use by the waferboard industry in this report.

HARVEST FOR THE WAFERBOARD INDUSTRY

The waferboard industry throughout the United States has grown at a remarkable rate. Northern Minnesota, because of its supply of aspen, has become the center of the industry. Four waferboard plants are operating in northern Minnesota and another is planned. Because the industry is young, projections could not be made on the basis of past history, as was done for other industries. So, consumption of National Forest aspen by the Minnesota waferboard industry was derived from projected use in construction.

First, we determined the amount of waferboard that would likely be used in building the average home in every 10th year from 1990 to 2030 (USDA 1982). The data used show a steady increase in the use of waferboard in house construction on the assumption that it will gradually replace plywood and other panel products (personal communication from R. Geimer, Forest Products Laboratory). The resulting figures were then multiplied by the predicted housing starts for those years (Marcin 1977) and adjusted upward by a factor (also derived from USDA (1982)) to account for waferboard use in other than housing construction.

Finally, we needed to determine the market area that would probably draw on the northern Minnesota timber supply. We expect the market area to be limited by high transportation costs. This will likely promote local waferboard plants where suitable forest resources are available. On this premise, we suggested two potential alternative markets—narrow and broad. We assumed a greater growth of the waferboard industry in the Midwest, South, and Rocky Mountains for the "narrow" market than for the "broad" market, and thus a narrower market for northern Minnesota wood. The narrow market then includes all housing starts in Minnesota and North and South Dakota, 30 percent of those in Iowa, and 10 percent of those in Wisconsin and Illinois. The broad market includes all starts in Minnesota and the Dakotas plus 60 percent of those in Iowa, 50 percent in Nebraska, and 30 percent in Wisconsin and Illinois.

Both these market areas may seem limited, considering the current location of waferboard plants in the United States. Recently, however, the waferboard industry has built plants in areas of the country where there was previously no waferboard production. These plants are generally smaller than earlier ones and utilize a variety of species. Given these changes in the industry, we assume that other sections of the north central region will begin producing waferboard and thus marketing of this product will become even more regional than it is now.

The volume of aspen harvested on the Chippewa and Superior National Forests for use by the northern Minnesota waferboard industry is then determined by converting waferboard quantities to cords (0.87 cord per thousand square feet of 3/8-inch waferboard), according to Harpole (1978), and multiplying by the market share for each forest (7 percent for the Chippewa and 12 percent for the Superior).

Assuming the "broad" market, the waferboard industry is projected to use 59,000 cords of aspen from the Chippewa National Forest and 101,000 cords from the Superior National Forest by 2030. If the "narrow" market area is assumed, the projected use of aspen would be 38,000 cords and 65,000 cords from the Chippewa and Superior National Forests, respectively (table 9).

Projections for aspen are divided into consumption of pulpwood and sawtimber and consumption by the waferboard industry. No attempt has been made to allocate the waferboard consumption by size class. Thus the pulpwood and sawtimber consumption projections for aspen may appear to be low.

FUELWOOD HARVESTS

Fuelwood harvest on the two National Forests in Minnesota has been minimal. USDA-Forest Service, Region 9, sale records indicate for the period 1971-1982 the Chippewa National Forest had an average annual cut of 228 cords from growing stock and the Superior only 5 cords. Most of this harvest was for residential use. Given the growth rate of fuelwood use per year projected by the Minnesota Department of Natural Resources (1981a), the largest anticipated annual harvest from growing stock would be 360 cords from the Chippewa National Forest and less than 50 cords from the Superior National Forest in 2030. Projected timber harvest for fuelwood use is not included in aggregate harvest from growing stock projections because it is less than 500 cords per year.

In 1982 and 1983, there were large increases in nonresidential fuelwood use, particularly by government institutions, a portion of which came from growing stock (Minnesota DNR 1983). Because this is a recent phenomenon, we do not have enough data to project the impact that nonresidential fuelwood

Table 9.—*Projected harvest of aspen from the Chippewa and Superior National Forests for use by the waferboard industry*

(In thousand cords)

Year	Northern Minnesota		Chippewa National Forest		Superior National Forest	
	Narrow market[1]	Broad market	Narrow market[2]	Broad market	Narrow market	Broad market
1990	16.7	26.5	1.2	1.9	2.0	3.2
2000	91.2	143.3	6.4	10.0	10.9	17.2
2010	296.6	467.0	20.8	32.7	35.6	56.0
2020	449.2	700.2	31.4	49.0	53.9	84.0
2030	544.6	844.6	38.0	59.1	65.4	101.3

[1]Narrow market: All housing starts in Minnesota, South Dakota, North Dakota; 0.3 of the housing starts in Iowa, and 0.1 of the housing starts in Wisconsin and Illinois.
[2]Broad market: All housing starts in Minnesota, South Dakota, North Dakota; 0.6 of the housing starts in Iowa; 0.5 of the housing starts in Nebraska; and 0.3 of the housing starts in Wisconsin and Illinois.

use may have upon harvests, particularly upon currently unused growing stock hardwood species.

However, we do know that the harvest of fuelwood is an important timber use in northern Minnesota, and so the vagaries of future demand could influence projected total harvests of timber.

OTHER POTENTIAL SOURCES OF DEMAND

An increase in demand for northern Minnesota timber for new products and industries is possible but of course not quantifiable. Expansion of the medium density fiberboard industry into northern Minnesota, for example, would increase the hardwood harvest on the Chippewa and Superior National Forests.

Press drying is another recent development that could increase the use of dense hardwoods in the paper industry. This process permits the use of hardwood pulp to make paper that has a higher compressive strength than is currently attainable, and gives the hardwood resource a new competitive economic advantage. However, because these and other new developments are still speculative we make no allowance for them in this report.

THE AGGREGATE PROJECTED TIMBER HARVEST ON THE CHIPPEWA AND SUPERIOR NATIONAL FORESTS

The projected harvest—assuming growth exceeds and thus does not restrict the harvest—is shown in tables 10 and 11 for the Chippewa and Superior National Forests. The harvest on the Chippewa National Forest is projected to grow 130 percent to 262,000 cords by 2030. Harvest on the Superior National Forest is projected to grow 133 percent to 435,000 cords. The timber resources in Minnesota are primarily on public land. Thus, existing and new industries must review timber resource statistics and future estimates as well as the intentions of public agencies to provide raw material necessary

Table 10.—*Projected harvest of timber grown on the Chippewa National Forest*

(In thousand cords)

Year	Aspen			Other hardwoods		Softwoods		Total
	Pulpwood	Sawtimber[1]	Waferboard	Pulpwood	Sawtimber	Pulpwood	Sawtimber	
1985	60	3.7	1.5	4.3	2.7	32.4	9.6	114.2
1990	69	3.6	1.9	4.8	2.6	33.3	9.4	124.6
2000	90	4.2	10.0	6.3	3.1	31.9	11.0	156.5
2010	106	4.8	32.7	7.4	3.7	23.9	12.6	191.1
2020	125	5.5	49.0	8.8	4.2	24.6	14.4	231.5
2030	148	6.0	59.1	10.3	4.5	18.4	15.8	262.1

[1]Conversion from table 7: 2.00 cords = MBF Scribner Decimal C log rule.

Table 11.—*Projected harvest of timber grown on the Superior National Forest*

(In thousand cords)

Year	Aspen			Other hardwoods		Softwoods		Total
	Pulpwood	Sawtimber[1]	Waferboard	Pulpwood	Sawtimber	Pulpwood	Sawtimber	
1985	103	4.0	1.9	7.4	2.1	55.7	12.7	186.8
1990	119	3.9	3.2	8.3	2.0	57.0	12.5	205.9
2000	155	4.5	17.2	10.8	2.4	54.6	14.7	259.2
2010	182	5.2	56.0	12.7	2.7	41.0	16.8	316.4
2020	214	5.8	84.0	15.0	3.1	42.2	19.1	383.2
2030	254	6.4	101.3	17.8	3.4	31.5	20.8	435.2

[1]Conversion from table 8: 2.00 cords = MBF Scribner Decimal C log rule.

for their capital investments. We assume that forest product industries will make rational decisions on how to best meet regional and national demand for forest products and that industrial capacity will not grow to exceed the supply of raw material.

Only on the Chippewa National Forest after 2020 does total projected harvest exceed projected growth (table 12). However, the projected harvest of aspen will exceed projected growth on both forests in the decade around the year 2000 (table 14). Harvests exceeding growth levels are entirely possible and rational due to the imbalance of age-class distributions and the over abundance of mature aspen. The projected growth of aspen was determined by multiplying the total projected growth on the Chippewa National Forest (table 12) by the aspen-birch type share of the total commercial forest area (table 14). Similarly, for the Superior National Forest, the projected growth (table 13) was multiplied by the aspen-birch type share. Current growth rates are similar for all species (Fuller 1979, Minnesota DNR 1981a), so we assume equal increases in growth for all species.

Future harvests are lower when we assume that the total projected harvest cannot exceed total projected growth for any year. On the Chippewa National Forest, timber harvested would increase 41 percent from 114,000 cords in 1985 to 161,000 cords in 2030. On the Superior National Forest, the increase would be 64 percent from 187,000 cords to 307,000 cords.

There are other methods of projecting harvest. Erkkila *et al.* (1982) and the Minnesota Department of Natural Resources (1981a) make projections for larger geographical regions that contain the Chippewa and Superior National Forests. These reports show future harvests similar to our projections.

CONCLUSIONS

We recognize that forecasting is tempered by future events that cannot be predicted with certainty. Our projections of future harvests were based on some reasonable assumptions such as population trends, timber growth, and future timber use. Under all assumptions, total timber harvest on both forests was projected to increase substantially by 2030.

The increasing demand for aspen may adversely affect total future harvest unless other species can be substituted for waferboard and other products. This implies that both forests should give high priority to the management of aspen. Forest product industries should also consider ways of substituting other species for aspen.

Table 12.—*Projected annual growth vs. projected total harvest on the Chippewa National Forest*

Year	Area	Growth	Growth	Unconstrained total harvest
	Thousand acres[1]	*Cords/acre*[2]	*Thousand cords*	
1985	562	.33	185	114
1990	574	.34	195	125
2000	574	.36	207	157
2010	574	.38	218	191
2020	574	.40	230	232
2030	574	.42	241	262

[1]Apportioned from projections in Wall (1981).
[2]Minnesota DNR (1981b).

Table 13.—*Projected annual growth vs. projected total harvest on the Superior National Forest*

Year	Area	Growth	Growth	Unconstrained total harvest
	Thousand acres[1]	*Cords/acre*[2]	*Thousand cords*	
1985	1,152	.33	380	187
1990	1,176	.34	400	206
2000	1,176	.36	423	259
2010	1,176	.38	447	316
2020	1,176	.40	470	383
2030	1,176	.42	494	435

[1]Apportioned from projections in Wall (1981).
[2]Minnesota DNR (1981b).

LITERATURE CITED

Adams, D. M. Effect of national forest timber harvest on softwood stumpage, lumber, and plywood markets: an econometric analysis. Res. Bull. 15. Corvallis, OR: School of Forestry, Oregon State University; 1977. 50 p.

Adams, D. M. An approach to estimating demand for national forest timber. For. Sci. 29(2): 289-300; 1983.

Blyth, J. E. Pulpwood production and consumption in the North Central Region by county, 1965. Resour. Bull. NC-2. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1966. 24 p.

Blyth, J. E. Pulpwood production and consumption in the North Central Region by county, 1966. Resour. Bull. NC-3. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1967. 27 p.

Blyth, J. E. Pulpwood production and consumption in the North Central Region by county, 1967. Resour. Bull. NC-6. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1969. 23 p.

Blyth, J. E. Pulpwood production in the North Central Region by county, 1968. Resour. Bull. NC-8. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1969. 22 p.

Blyth, J. E. Pulpwood production in the North Central Region by county, 1969. Resour. Bull. NC-11. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1970. 23 p.

Blyth, J. E. Pulpwood production in the North Central Region by county, 1970. Resour. Bull. NC-13. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1971. 22 p.

Blyth, J. E. Pulpwood production in the North Central Region by county, 1971. Resour. Bull. NC-17. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1973a. 21 p.

Blyth, J. E. Pulpwood production in the North Central Region by county, 1972. Resour. Bull. NC-18. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1973b. 16 p.

Table 14.—*Projected growth of aspen, projected unconstrained harvest of aspen, and projected total harvest with species growth as a limiting constraint on the Chippewa and Superior National Forests*

(In thousand cords)

	Chippewa National Forest			Superior National Forest		
Year	Aspen growth	Unconstrained aspen harvest	Constrained total harvest	Aspen growth	Uncontrained aspen harvest	Constrained total harvest
1985	85	65	114	179	109	187
1990	65	75	125	188	126	206
2000	95	105	148	199	177	259
2010	100	144	148	210	244	284
2020	106	180	159	221	304	302
2030	111	214	161	232	362	307

Blyth, J. E. Pulpwood production in the North Central Region by county, 1973. Resour. Bull. NC-27. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1975. 16 p.

Blyth, J. E.; Hahn, J. T. Pulpwood production in the North Central Region by county, 1974. Resour. Bull. NC-29. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1976. 26 p.

Blyth, J. E.; Hahn, J. T. Pulpwood production in the North Central Region by county, 1975. Resour. Bull. NC-34. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1977. 22 p.

Blyth, J. E.; Hahn, J. T. Pulpwood production in the North Central Region by county, 1976. Resour. Bull. NC-35. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1978. 22 p.

Blyth, J. E.; Smith, W. B. Pulpwood production in the North Central Region by county, 1977. Resour. Bull. NC-41. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1979. 23 p.

Blyth, J. E.; Smith, W. B. Pulpwood production in the North Central Region by county, 1978. Resour. Bull. NC-50. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 23 p.

Blyth, J. E.; Smith, W. B. Pulpwood production in the North-Central Region by county, 1979. Resour. Bull. NC-56. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981. 22 p.

Blyth, J. E.; Smith, W. B. Pulpwood production in the North-Central Region by county, 1980. Resour. Bull. NC-59. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 21 p.

Carpenter, E. M. Flakeboard developments and effects on markets for roundwood in Minnesota. The Consultant 26(1): 17-22; 1981.

Connaughton, K. P; Haynes, R. W. An evaluation of three simplified approaches to modelling the regional demand for national forest stumpage. For. Sci. 29(1): 3-12; 1983.

Data Resources, Inc. Demand on the Minnesota timber resource. Data Resources, Inc.; 1980. 87 p.

Erkkila, D. L.; Rose, D. W.; Lundgren, A. L. Estimating economic impacts of timber based industry expansion in northeastern Minnesota. Gen. Tech. Rep. NC-82. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 21 p.

Fuller, B.; Veltkamp, J. Aspen resources and the waferboard industry in Minnesota. Wood Rev. 2(28): 1; 1979.

Harpole, G. B. Overview of structural flakeboard costs. In: Structural flakeboard from forest residues. Gen. Tech. Rep. WO-5. Washington, DC: U.S. Department of Agriculture, Forest Service; 1978: 140-149.

Haynes, R. W. A derived demand analysis to estimating linkages between stumpage and lumber market. For. Sci. 23(2): 281-288; 1977.

Haynes, R. W.; Connaughton, K. P.; Adams, D. M. Projections of the demand for national forest stumpage by region, 1980-2030. Res. Pap. PNW-282. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1981. 13 p.

Jakes, P. J. Minnesota's aspen resource. Res. Note NC-268. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1981. 4 p.

Jakes, P. J.; Raile, G. K. Timber resource of Minnesota's Northern Pine Unit, 1977. Resour. Bull. NC-44. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 54 p.

Koch, P.; Springate, N. C. Hardwood structural flakeboard—development of the industry in North America. J. For. 81(3): 160-161; 1983.

Marcin, T. Outlook for housing by type of unit and region, 1978-2020. Res. Pap. FPL 304. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; 1977. 44 p.

Minnesota Department of Natural Resources. Minnesota wood residue studies. Project No. 4. St. Paul, MN: Minnesota Department of Natural Resources; 1980. 14 p.

Minnesota Department of Natural Resources. Minnesota timber resource availability. Unpubl. Rep. St. Paul, MN: Minnesota Department of Natural Resources in cooperation with the Minnesota Energy Agency; 1981a. 13 p.

Minnesota Department of Natural Resources. Residential fuelwood demand in Minnesota, 1979-1980. Unpubl. Rep. St. Paul, MN: Minnesota Department of Natural Resources; 1981b. 10 p.

Minnesota Department of Natural Resources. Status of wood energy use in Minnesota with emphasis on automated systems. St. Paul, MN: Minnesota Department of Natural Resources; 1983. 13 p.

Rockel, M.; Buongiorno, J.; Lothner, D. C.; Kallio, E. Future consumption of timber grown in northern Minnesota, 1980-2030. Res. Pap. NC-244. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1983. 15 p.

Spencer, J.; Ostrom, A. J. Timber resources of Minnesota's Aspen-Birch Unit, 1977. Resour. Bull. NC-43. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1979. 52 p.

U.S. Department of Agriculture, Forest Service. Timber cut and sold on National Forests under sales and land exchanges, 1964-1982. Unpubl. Rep. Milwaukee, WI: U.S. Department of Agriculture, Region 9; 1982a. 624 p.

U.S. Department of Agriculture, Forest Service. An analysis of the timber situation in the United States, 1952-2030. For. Resour. Rep. 23. Washington, DC: U.S. Department of Agriculture, Forest Service; 1982b. 499 p.

Wall, B. R. Trends in commercial timberland area in the United States by state and ownership, 1952-1977, with projections to 2030. Gen. Tech. Rep. WO-31. Washington, DC: U.S. Department of Agriculture; 1981. 28 p.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1986—653-535/20126

Orr, Blair; Buongiorno, Joseph; Young, Timothy; Lothner, David C.; Kallio, Edwin.

Future timber harvests on the Chippewa and Superior National Forests in Minnesota. Resour. Bull. NC-89. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1985. 11 p.

Timber harvests on the Superior and Chippewa National Forests in Minnesota are projected to increase substantially by 2030. The increasing demand for aspen may affect the total harvest. Both forests need to give high priority to aspen management.

KEY WORDS: Pulpwood, saw logs, fuelwood, forecasting, consumption.